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FALL MIGRATION OF SAW-WHET OWLS AT PRINCE EDWARD POINT, ONTARIO

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The Saw-whet Owl (*Aegolius acadicus*) is a permanent resident in woodlands across extreme southern Canada from Vancouver Island, British Columbia to Cape Breton, Nova Scotia. In Ontario and Quebec, this species occurs to 50°N (Godfrey 1966). Bent (1938) thought movements of saw-whets were too irregular to be true migration, whereas Taverner and Swales (1911) considered the Saw-whet Owl to be migratory. More recent data substantiate this claim. Spring movements have been described in the Toronto, Ontario, area (Catling 1971) and at Whitefish Point, Michigan (Kelley and Roberts 1971a, b). Fall migration has been reviewed by Woods (1972). Mueller and Berger (1967) reported Saw-whet Owls to be regular fall migrants in Wisconsin.

Holroyd and Woods (1975), analysing banding records and recoveries for 1955–1969, showed an annual autumnal movement from Canada by saw-whets that followed Ohio and Mississippi rivers and the Atlantic Coast. Systematic studies of autumn migration in Ontario have not been reported in the literature even though 48% of the 4802 Saw-whet Owls banded in North America during 1955–1969 were banded there (Holroyd and Woods 1975). We do not know how many of these were in autumn migration.

Here we document the movements of Saw-whet Owls through Prince Edward Point in fall, the sex and age profiles of the birds in the flights, and the relationship between these movements and weather parameters.

STUDY AREA AND METHODS

Data were gathered on 190 ha surrounding the lighthouse at Prince Edward Point (43°57′N, 76°54′W), on the eastern tip of the Long Point Peninsula on the north shore of Lake Ontario 40 km southwest of Kingston (Fig. 1). The area is well known for heavy passerine migrations (Weir 1972a, b) and autumnal raptor flights (Goodwin 1974). Much of the Point cleared earlier for farming now comprises extensive ungrazed grassland with scattered red cedar (*Juniperus virginianus*) and small deciduous bushes. Remaining woodland consists mainly of deciduous trees and white cedar (*Thuja occidentalis*).

There were 3 major mist net areas: (1) area A (cedar woods)—used all 4 years of study; (2) area B at the extreme tip of the Point—used 1976 and 1978; and (3) area C (Point Traverse)—used 1977 and 1978. Nets (up to 120 m in length) were placed perpendicular to the main axis of the woods in laneways cut through the bushy openings between wooded areas, in natural clearings, in woods and in open areas at the edge of woods. Nets were 2.5–3.5 m high. Mesh sizes were either 30 mm or 36 mm, and most were tethered. Nets were usually opened at dusk and closed at dawn. During inclement weather nets were closed. Nets were

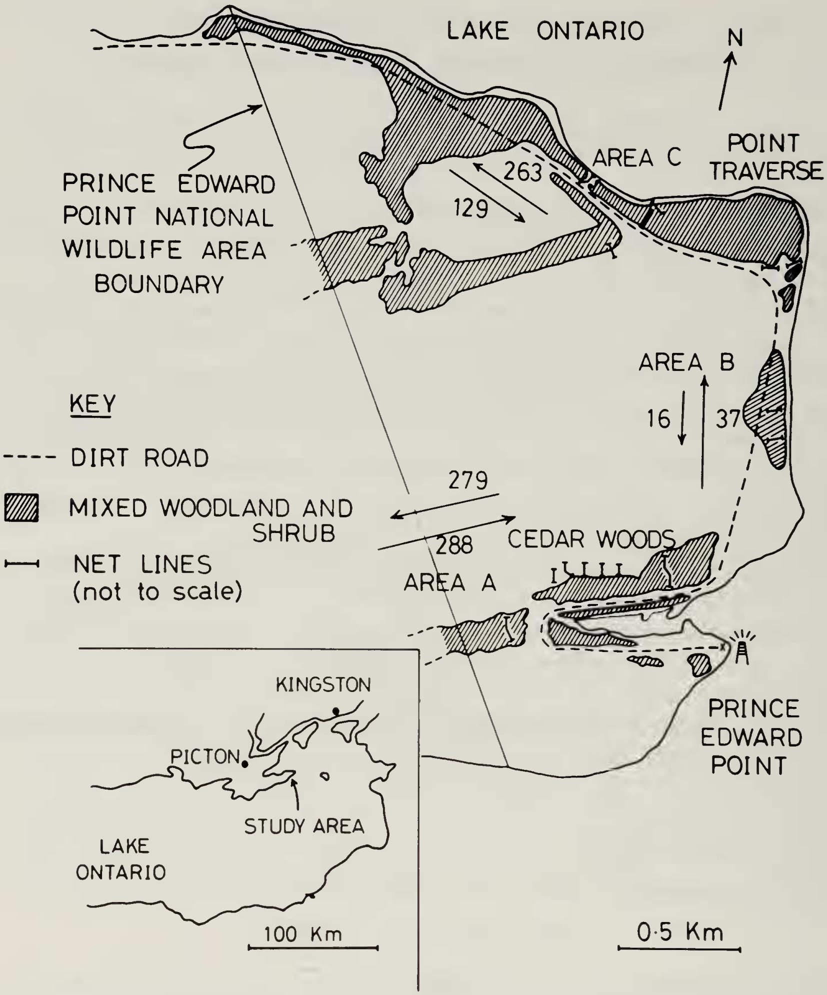

FIG. 1. Saw-whet Owl migration study area at Prince Edward Point, Ontario.

set every night between 18 Sept. to 6 Nov., 23 Sept. to 6 Nov. and 24 Sept. to 4 Nov. in 1976, 1977 and 1978, respectively. In 1975, nets were set on 10 nights between 27 Sept. to 9 Nov.

Data were collected by a number of banders, often with help from several volunteers. Nets were checked at intervals of 1–2 h. Captured owls were removed, placed in numbered cloth bags and taken to the observatory for processing. The side of the numbered net the owl flew into was recorded. Birds were weighed and examined for plumage and molt details. Both wings (chord) were measured on each bird.

Weather conditions and wind velocity were recorded at regular intervals throughout the night. These data were supplemented by records from the Atmospheric Environment Service

TABLE 1
COMPARISON OF AUTUMN SAW-WHET OWL CATCHES AT PRINCE EDWARD POINT

	1975	1976	1977	1978
HY owls/index[1]	—	95/4.7	389/7.9	123/2.4
PHY owls/index	—	94/4.7	163/3.3	180/3.6
Total owls/index	83/36.5	190/9.4	552/11.2	303/6.0
Average net area (m^2)	227	592	1175	1265
Nights with >100 m^2 net area	10	34	42	40

[1] Owls per 1000 m^2 of net per night.

for 3 nearby sites: (1) Main Duck Island, 19 km off shore to the east; (2) Trenton, 60 km WNW; and (3) Kingston, 40 km NE.

Owls were aged by relative color of primary and secondary flight feathers. Presence of both dark (unworn) and paler (worn) flight feathers indicated the partial postbreeding remex molt typical of a post hatching year (PHY) bird. Birds with flight feathers of uniform coloration without wear denoted hatching year (HY) individuals. Birds that showed pale uniform coloration in flight feathers accompanied by worn tips were also assigned as PHY. One bird initially identified as PHY in 1977 had all dark feathers when recaptured in 1978, suggesting that some at least of the PHY birds have a complete postbreeding molt when caught. Thus our classification of birds as either HY or PHY was not error-free.

Although many owls were in various stages of body molt, none showed any sign of molting remiges or rectrices, other than the occasional asymmetrical sheathed feather which probably reflects replacement of a lost feather. The presence of dark and light feathers in the remiges suggests an interrupted wing molt.

Saw-whet Owls show reversed sexual dimorphism; the average female has longer wings and weighs more than males (Earhart and Johnson 1970). There is overlap in both wing length and body weight of the sexes. Birds with wings 135–140 mm were classified as sex unknown (U). Because of overlap in wing length, we used the criteria males ≤134 mm and females ≥141 mm to assign sex (modified from Wood 1969, Sheppard and Klimkiewicz 1976, North American Bird Banding Techniques 1977).

To analyse age and sex dependent differences in migration times, birds classified as HY♂, HY♀, PHY♂ and PHY♀ were examined. In each year when these categories were identified, the season was divided into 3 time periods—early, middle and late—such that approximately equal numbers of owls were assigned to each period.

RESULTS

Table 1 shows the number of owls caught and the amount of netting conducted 1975–1978. The index used is that described by Mueller and Berger (1967). Since the banding in 1975 was exploratory, intermittent and concentrated on peak migration dates, the migration index for that year is not comparable with those of the other 3 years. In 1975, no attempt was made to age or sex the birds. During 1976–1978, the number of adult owls, corrected for intensity of netting, remained relatively constant (PHY in-

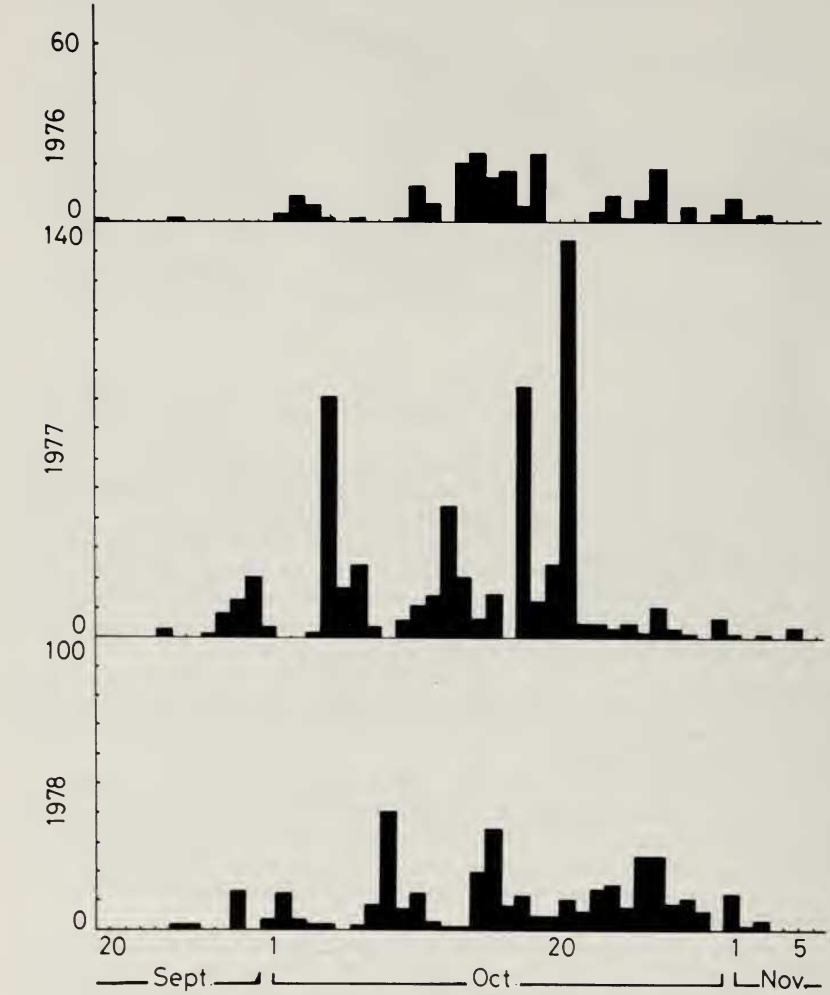

FIG. 2. Nightly Saw-whet Owl banding totals at Prince Edward Point, 1976–1978.

dex: 3.3–4.7), whereas there was considerable fluctuation in the relative numbers of hatch year birds (HY index: 2.4–7.9). Of the annual fluctuation in owl totals, 84–100% are accounted for by the fluctuation of HY birds.

Seasonal patterns of capture are shown in Fig. 2. Most owls were caught in October with a peak in mid-month. Numbers caught fluctuated daily. By about the end of the third week of October 75% of the owls were caught; 50% of all captures were during the second and third weeks of October.

TABLE 2
SEX AND AGE DISTRIBUTION OF SAW-WHET OWLS, 1976–78

Year	HY♂	HY♀	PHY♂	PHY♀	HY U	PHY U	U U	Total
1976	46	16	36	30	35	26	1	190
1977	187	84	62	49	118	52	0	552
1978	54	23	55	57	46	68	0	303

Sex and age distribution.—Table 2 shows the relative distribution of all the age and sex classes 1976–1978. In each of these years, respectively, the ratios HY♂ to HY♀ were 2.9, 2.2, 2.4 and PHY♂ to PHY♀ were 1.3, 1.3 and 1.0. Since sex could not be assigned in 32.6%, 30.8% and 37.6%, of the birds, respectively, making definitive statements on sex ratios was difficult. For owls of known sex, there is a significant departure in all 3 years from the distribution expected, assuming that all ages and sex classes move through in a similar seasonal pattern (Table 3). In 1976 and 1978, females migrated significantly earlier in the season than males ($\chi^2_2 = 9.55$, $P < 0.010$ and $\chi^2_2 = 19.19$, $P < 0.001$, respectively) while in 1977 the difference was not significant ($\chi^2_2 = 2.99$, $P < 0.10$). In 1977, the year of high numbers of HY birds, the young birds moved through significantly earlier than the older birds ($\chi^2_2 = 30.24$, $P < 0.001$) and the young females preceded the young males ($\chi^2_2 = 6.71$, $P < 0.05$). In 1976, no significant difference in timing was observed between HY and PHY ($\chi^2_2 = 0.31$, $P < 0.90$), but HY females preceded HY males ($\chi^2_2 = 10.77$, $P < 0.005$). In 1978, HY birds migrated later than PHY ($\chi^2_2 = 10.83$, $P < 0.005$), the reverse of the situation in 1977.

Local distribution.—Patterns of movement and directions of flight could not be observed directly in most cases. Although a netted owl could have flown in from anywhere across 180°, we have some insight into predominant flight directions in the 3 major net areas by recording the side of the net into which the owl had flown. In areas A and C, the nets were aligned in a north-south direction, thus intercepting predominantly east-west movement, while in area B, predominantly north-south movement was intercepted. In area A, there was no predominant flight direction in any of the 3 years (Table 4). In area B, 70% of 53 owls were caught flying north. In area C, 67% of 392 were caught flying west. The predominant flight directions are shown in Fig. 1.

Weather.—Analyses of daily synoptic weather maps for the autumns of 1976 and 1977 (Ludlum 1976, 1977) showed that almost always when 10 or more birds were caught, the Prince Edward Point area experienced a high pressure system pushing out a low towards the northeast. The relative

TABLE 3
SEASONAL MOVEMENT OF OWLS, CLASSIFIED IN TERMS OF AGE AND SEX

		Time of season					
		Early[1]		Mid		Late	
Year	Age/sex	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
1976	HY ♀	10	5.1	4	5.3	2	5.6
	HY ♂	9	14.7	17	15.1	20	16.2
	PHY ♀	12	9.6	9	9.8	9	10.6
	PHY ♂	10	11.5	12	11.8	14	12.7
		$\chi_6^2 = 11.92$, $P < 0.05$					
1977	HY ♀	42	28.4	31	31.4	11	24.2
	HY ♂	70	63.2	68	70.0	49	53.9
	PHY ♀	7	16.6	22	18.3	20	14.1
	PHY ♂	10	20.9	22	23.2	30	17.9
		$\chi_6^2 = 37.74$, $P < 0.001$					
1978	HY ♀	6	7.3	9	7.3	8	8.3
	HY ♂	8	16.9	18	16.9	27	19.2
	PHY ♀	31	18.2	18	18.2	8	20.6
	PHY ♂	15	17.6	15	17.6	25	19.9
		$\chi_6^2 = 27.35$, $P < 0.001$					

[1] See Methods.

positions of the centers of the 2 pressure cells varied, but in every case their combined circulatory effect was to produce NW winds and clear skies after the passage of a cold front. The movement of owls was assessed in relation to wind direction and speed, and cloud cover over the Point.

For the initial analysis, observations were placed in either 1 of 4 wind directions (NE, SE, SW, NW), or calm, and the night was divided into 3 time periods (18:00–22:00, 22:00–02:00 and 02:00–06:00). In each time period, the number of captures and the total hours when wind was blowing in that direction while the nets were open were tabulated as a function of wind direction. The results of the data for 1976, 1977 and 1978 are similar; 1977 data are illustrated (Table 5). Trapping success was linked with wind direction and most owls were caught when winds were blowing from the north-west quadrat. When wind direction was further subdivided, it was found that most owls were caught during WNW winds (Fig. 3). Fewest owls were caught when the winds blew from NE through S. None was caught during the 3% of the time when the wind speed exceeded 25 km/h.

Significantly fewer owls were caught during the first 4 h of the night than during the later periods (Table 5; $\chi^2_1 = 21.04$, $P < 0.001$ from col-

TABLE 4

DIRECTIONS OF FLIGHT OF OWLS CAUGHT IN 3 AREAS, 1976–1978

	Predominant flight direction	Year 1976	1977	1978	Total
Area A	East	75	125	88	288
	West	82	131	66	279
Area B	North	9	—[1]	28[2]	37[2]
	South	3	—	13	16
Area C	East	—[1]	93	36	129
	West	—	192[2]	71[2]	263[2]

[1] No nets.
[2] $P < 0.05$.

umns 2 and 3). However, this was the time when nets were being opened, and thus could influence the results. Wind directions were distributed equally among the 3 time periods and no bias is introduced because of different wind directions at different times of the night.

The number of Saw-whet Owls netted as a function of cloud cover was computed. In each year, 1976–1978, the results are similar; significantly more owls were caught in the <20% cloud category. Following the procedure adopted for wind analysis, the cloud data from 1977 are illustrated in Table 6.

Recaptures.—Among the owls caught at the Point, 25, 134 and 52 were recaptured there within the same season in 1976, 1977 and 1978, respectively and include 0, 20 and 5 birds recaptured a second time. The time

TABLE 5

NUMBER OF OWLS CAPTURED AS A FUNCTION OF WIND DIRECTION AND TIME OF NIGHT, 1977

Wind direction	No. of Owls Time 18-22	22-02	02-06	Total	No. of h 18-22	22-02	02-06	Total
Calm	6	22	37	65	7.5	21	9	37.5
NE	14	19	30	63	31	54	61	146
SE	1	0	0	1	17	29	25	71
SW	6	29	100	135	15.5	33.5	34	83
NW	44	158	86	288	15	30.5	38	83.5
Total	71	228	253	552	86	169	167	421
Owls/h	0.8	1.4	1.5	1.3				

$\chi_4^2 = 479.5$, $P < 0.001$.

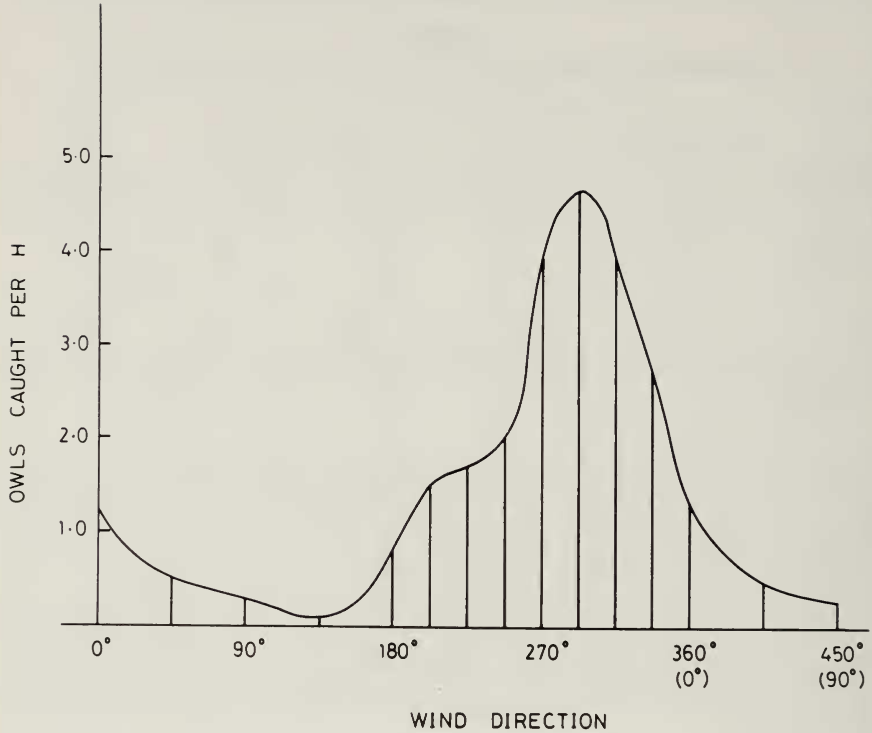

FIG. 3. Predominant wind direction when owls were caught.

between initial capture and recapture, including second recaptures, is shown in Fig. 4. The percentages of the different age and sex categories among recaptured birds is not significantly different from that of the total banded sample ($\chi^2_3 = 4.11$, $P < 0.20$).

Recaptured owls showed weight changes between capture and recap-

TABLE 6

NUMBER OF OWLS CAPTURED AS A FUNCTION OF CLOUD COVER, 1977

	Percent cloud cover			
	<20%	30–90%	>90%	Totals
Owls caught	436	42	74	552
Owls expected	243	67	251	552

$\chi_1^2 = 308.5$, $P < 0.001$.

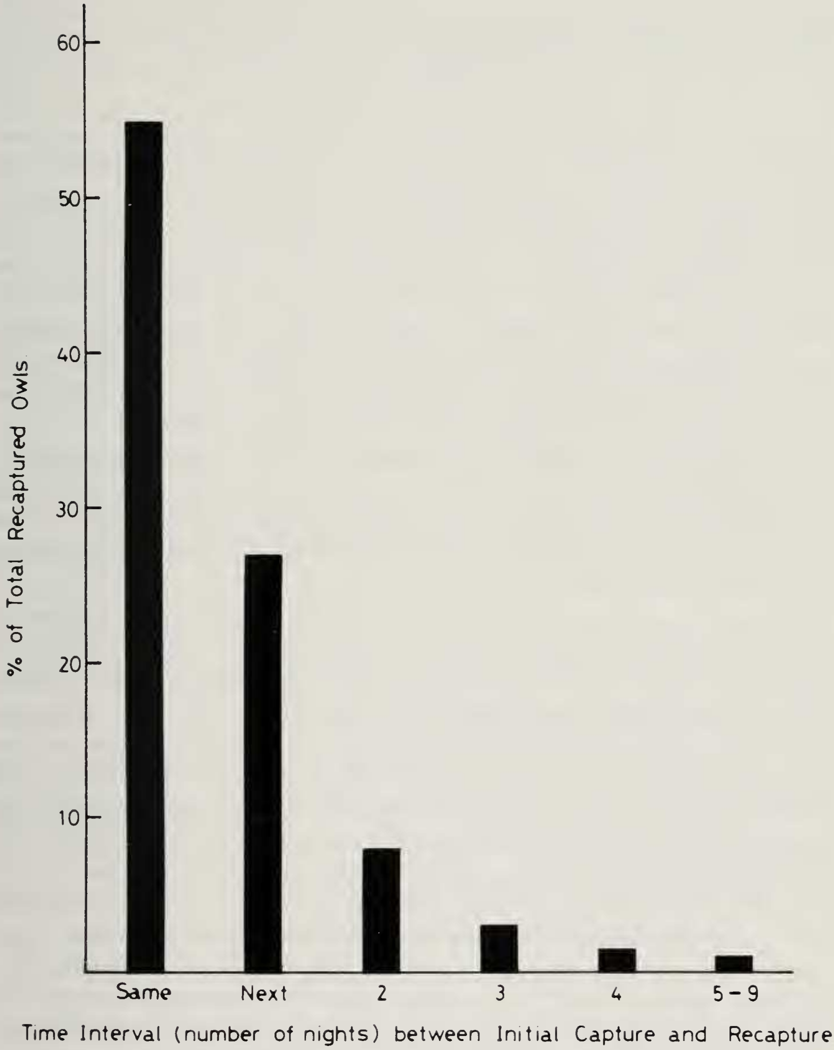

FIG. 4. Number of nights between capture and recapture of owls.

ture. Some 63% lost weight, 29% gained and 8% showed no change. Among birds recaptured within 30 h of the original captures, (i.e., on the same or succeeding night), 73 had lost weight. There was a strong positive correlation between weight loss and number of hours between capture and recapture (R = 0.611, $P < 0.001$) for those birds which had lost weight, approximately 0.3 g/h. Birds caught more than 30 h later showed a less consistent pattern, but this is expected since these birds are more likely to have eaten in the intervening time.

DISCUSSION AND CONCLUSIONS

Evidence of migration of owl species is difficult to obtain but we have gained some insight into what is happening with the Saw-whet Owl. This study supports the thesis that saw-whet's migration is regular in large numbers and is not irruptive as is the Goshawk (*Accipiter gentilis*) (Bent 1937, Mueller et al. 1977) or Great-gray Owl (*Strix nebulosa*) (Vickery and Yunick 1979). The autumn arrival times and quartile dates of the Saw-whet Owl at Prince Edward Point show annual consistency not characteristic of irruptive species. In addition, the numbers of saw-whets netted in autumn 1978 do not parallel numbers of those owl species that irrupted into eastern Ontario in winters 1978–1979 (Bell et al. 1979).

The year-to-year variation in saw-whet numbers after correcting for netting effort seems to result from variations in the numbers of HY birds, possibly reflecting variation in annual reproductive success north of Lake Ontario. This may account for the so-called invasional characteristic of the species (Bent 1938).

Timing of migration in terms of age when combining sexes appears to be random. There was no significant difference in 1976, HY preceded PHY in 1977 (the year of large numbers of HY birds) and HY followed PHY in 1978. Mueller and Berger (1967) noted no consistent difference between the time HY and PHY birds migrate. However, the data suggest that cues which lead to migration affect the sexes differentially. In 1976 and 1978, females (HY and PHY as separate or combined) migrated significantly earlier than males (HY and PHY separate or combined); in 1977 HY females preceded HY males. On no occasion did males precede females. If the larger heavier females are more vulnerable to a diminishing food supply than males, they may leave the breeding areas earlier. There is no indication from recaptures that 1 age class migrates more slowly than the other, nor that the 2 sexes differ in the length of time which they remain at the Point. The cause of differential sex migration is unknown.

There is a strong correlation of NW winds and clear skies with high catches of owls. In this respect, saw-whets are similar to nocturnal passerines (Bennett 1952, Lack 1960) and diurnal birds of prey (Bagg 1971).

Since the majority of migrating owls cannot be seen, their movements must be inferred indirectly from the patterns of local movement. Their migration direction is southwards in autumn and several concentration points exist along the north shores of Lake Erie and Lake Ontario (Holroyd and Woods 1975). Woodford (1959) showed a general SW displacement in autumn from Toronto. It seems that saw-whets, as they move southwards during October, are concentrated by the lower Great Lakes and their response to the eastern Lake Ontario shoreline determines their arrival route to Prince Edward Point. We suggest the 2 most likely routes are either across the water from the N-NE direction of Kingston (Fig. 1), or over land, out along the peninsula from the west. Either route is consistent with NW winds.

If the owls move from the NE by following the Lake Ontario shoreline, then NW winds may displace the birds laterally, thereby forcing them away from their preferred route and out over the water. Wind drifted migrants are common on the Atlantic Coast (Baird and Nisbet 1960, ref. therein). However, the sheer number of owls and capture sites suggest that the majority arrive at the Point via the land route, are swept downwind (eastwards) from the mainland and backtrack westwards when they reach the end of the peninsula. The findings of a predominantly westward flight of owls caught in area C and northward flight in area B are consistent with this hypothesis. There is 1 problem raised by it, however. Why do we not find an excess of birds flying east into the nets of area A? Perhaps the randomness of the catch here is caused by owls pausing to hunt and feed. It is possible that nets located closer to the shore would intercept more birds flying east.

Additional information reinforces our view that most of the owls arrive at and escape from the Point via the land route. Water barriers affect the movement of diurnal migrants and they respond by following well-marked topographical features (e.g., Cape May or Nantucket) (Baird and Nisbet 1960, Richardson 1972). In the Netherlands, the Chaffinch (*Fringilla coelebs*) shifts its flight path over the land and away from the sea (Van Dobben 1953). Ulfstrand (1960) notes Scandinavian studies show that along coastlines, where NW winds come in at an angle of 90° in relation to the primary SW direction of migration, the diurnal migrants are forced over the coastline at new angles, a fact of great importance for their reactions.

The Black-capped Chickadee (*Parus atricapillus*) in its southward diurnal movement responds to the Great Lakes by flying along the shorelines and following them to places where short water crossings or land bridges permit onward movement in their preferred direction (Bagg 1969). Topography induces different directions of movement in different parts of the same shoreline. In the Toronto area, chickadees fly west following the north shore of Lake Ontario whereas in the eastern section of Lake Ontario, they fly eastwards along the north shore out along the peninsula leading to Prince Edward Point (Bagg 1969).

Our own observations at the Point over the past 10 years show that hawks and Blue Jays (*Cyanocitta cristata*) also follow the shoreline out to Prince Edward Point. The numbers are greatest on W-NW winds and upon reaching the tip of the peninsula, they spiral upwards and backtrack westwards against the wind. This tendency is well known in low flying birds which follow lines of diversion into the wind (Lack and Williamson 1959, Baird and Nisbet 1960, Lack 1963). Such birds seem to be in retromigration, returning to their preferred direction even though flying against the wind expends extra energy (Nisbet 1957, Lack 1959).

No studies known to us mention owls so we can only speculate that they behave as several species of hawks which normally avoid water crossings, but will cross water in certain geographical locations (Wood 1933, Goodwin 1979). We do not know whether any number of saw-whets cross Lake Ontario from Prince Edward Point. We have not carried out netting on the small islands located several km offshore. Perhaps some owls use the islands as stepping stones into New York State. Saw-whets have appeared occasionally aboard lake steamers (Taverner and Swales 1911; Perkins 1964, 1965) and in migration disasters over Lake Huron (Saunders 1907, Goodwin 1970).

A comparison of owl numbers at Prince Edward Point with those reported at Cedar Grove, Wisconsin (Mueller and Berger 1967) shows considerably higher indices at the Point (9.4, 11.2 and 6.0 vs 1.14, 2.79 and 2.54). These differences probably reflect Prince Edward Point's location on the north shore of a major body of water which impedes southerly migration.

SUMMARY

The migration of Saw-whet Owls during autumns of 1975 through 1978 was discussed. During that time 1128 birds were captured. Yearly fluctuation in the number of owls caught is largely accounted for by the fluctuations in number of hatch year birds. The highly significant correlation of NW winds and clear skies with owl catches suggests that these conditions stimulate migration in the Prince Edward Point area. In 1977, juvenile birds of both sexes migrated significantly earlier in the fall than adults, whereas in 1976 and 1978, female birds of both age categories migrated earlier in the season than males.

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DEPT. CHEMISTRY AND CHEMICAL ENGINEERING, ROYAL MILITARY COLL. KINGSTON, ONTARIO, CANADA (RDW); DEPT. BIOLOGY, QUEEN'S UNIV., KINGSTON, ONTARIO (FC); DEPT. PHYSICS, ROYAL MILITARY COLL., KINGSTON, ONTARIO (MHE); AND DEPT. MICROBIOLOGY, QUEEN'S UNIV., KINGSTON, ONTARIO (RBS). ACCEPTED 17 MAR. 1980.

RESEARCH GRANTS

The Eastern Bird Banding Association and the Western Bird Banding Association are each offering a research grant of $250 in aid of research using bird banding techniques or bird banding data. Applicants should submit a resume of his or her ornithological or banding background, the project plan and budget to the joint selection committee chairman: Robert C. Leberman, Powdermill Nature Reserve, Star Route South, Rector, Pennsylvania 15677. No formal application forms are available, and the amount requested should not exceed $250. The deadline for receipt of applications is 15 March 1981.